In this manner Mr. T, known to be somewhat color blind to red, was examined, and I found that putting the amount of red light perceived by myself as 100 he perceived only 63.04 per cent. It was also ascertained that his vision was not only defective for red light, but to a less extent for green, he perceiving only 85.5 per cent. of it. A set of control experiments were then made on Mr. T. The blue glass was replaced by the green glass and the red glass was put next to the movable lamp, and for the moment it was assumed that the vision of Mr. T for green light was the same as my own—in other words, green instead of blue light was made the standard, and it was temporarily assumed that both of us were equally affected by green light. The amounts of red perceived by him in two experiments were 71.3 and 70 per cent., as compared with 100 by myself. But as he really perceived only 85.5 per cent. of the green light, to obtain the correct value of his perception of red in these two experiments we must take $\frac{85.5}{100}$ of $70.6 = 60.4$, which differs from the value for the red directly obtained by 2.6 per cent. It may be remarked, in passing, that this case of color blindness was not suspected till revealed by some flicker experiments with colored discs made by myself in Mr. T's presence.

A second case which I examined was of a more pronounced character, and had previously been known to exist. Out of 100 rays of red light perceived by myself, Mr. A. was affected only by 19.44 per cent., violet-blue, as before, being the standard. With the same standard only 86.9 per cent. of the green light was perceived. Taking green as the standard, 22.9 and 23.3 per cent. of red was perceived, and as before, $\frac{86.9}{100}$ of $23.1 = 20$, instead of 19.44, obtained in the direct determination.

The third case of Mr. B. was quite similar to the last, a well-known and pronounced instance of red color-blindness. Violet-blue being taken as the standard, 20.4 per cent. of red was perceived, and 83.8 of green light. Green being made the standard, 25.5 per cent. of red light was perceived, and as before $\frac{83.8}{100}$ of $25.5 = 21.36$, instead of 20.4, as directly obtained when using violet-blue light as the standard.

In these determinations, as in all others of a similar kind which I have superintended, the persons experimented on moved the lamp themselves, without assistance from me, and, owing to the presence of screens, were in complete ignorance of the results they were obtaining. I have been quite surprised to find how quickly persons wholly unused to physical experiments of any kind were able to obtain reliable results with the flicker photometer as now arranged. They needed a little more time, and their probable error was somewhat larger than is the case with an experienced person. Each result given above is obtained from the mean of from ten to fifteen readings registered on the filet of paper connected with the moving lamp. Finally, it is to be remembered that in all of these determinations I have for the time being assumed my own color-vison to be strictly normal, which, now that we have this accurate photometric method, is hardly quite a safe proceeding for any man, or even woman, as some of my unpublished results show.

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THE OPENING OF THE NEW LABORATORY FOR PHYSICAL CHEMISTRY IN LEIPSIC.

A SHORT time ago an abstract of the address delivered by Nernst at the opening of the new laboratory for physical chemistry at the University of Göttingen was given in SCIENCE. The University in Leipsic has

recently constructed a physical chemical laboratory, which not only equals, but apparently far surpasses, the structure in Göttingen.

As Ostwald points out in the first pages of the pamphlet, 'Das physikalisch-chemische Institut der Universität Leipzig, und die Feier seiner Eröffnung,' Leipsic has taken the lead for a considerable time in physical chemistry. It is true that Kopp worked in Heidelberg as early as 1864, but the work of Kopp belongs distinctly to the older school. The questions raised by him were such as these: What is the relation between the composition of compounds and their physical properties, and what is the relation between the constitution of compounds and their physical properties? Such work, of course, was and is still of great value, but the questions it had to deal with were quite different from those asked by the physical chemist of to-day, who employs also entirely different methods in answering his questions.

Ostwald calls attention to the fact that Kopp was an investigator in his line, rather than a teacher; also to the very poor equipment with which he was provided, the calorimeter with which Kopp's measurements of specific heat were made, being constructed out of a brass match-box. Kopp was invited to Leipsic, but declined the call.

In 1871 Gustav Wiedemann was appointed to the first chair for teaching physical chemistry in Leipsic. On the retirement of Hankel, in 1887, he gave this up, and devoted his entire attention to physics. This left the chair which had been occupied by Wiedemann vacant, and to this Ostwald was called from Riga. He was given the laboratory formerly built for the agricultural chemist Knop, and here all of his work up to the present has been done. The entire laboratory was not given up to physical chemistry, but a part of it was devoted to general elementary chemistry, qualitative and quantitative analysis, and pharmacology. This provision was a wise one, since Ostwald's first semester opened with two students, and the number was reduced to one at the close of the second. The number of students increased until at present it has reached about thirty. In the old laboratory only three small, poorly lighted and modestly equipped rooms were devoted to students in physical chemistry. The difficulties which were being constantly met with are well remembered by everyone who worked with Ostwald during the first ten years of his professorship in Leipsic. The water supply was poor; the method of heating was bad; and, as he himself says, the rooms were too narrow to permit the use of telescope and scale in physical measurements.

When we take into account the conditions under which Ostwald has done his work, and then consider the quantity and quality of the work which has come from his laboratory, we are again reminded, in a forcible manner, of the fact that scientific investigation depends far less upon the equipment than upon the man.

But the 'Leipsic school' of physical chemistry finally completely outgrew its quarters, and a new and elegant laboratory has now been provided. This consists, in reality, of two laboratories, a physical and a chemical. The first story is devoted to the physical, and physical chemical work proper.

One or two points in connection with the equipment of this part deserve special comment. The large research laboratory is provided with one huge thermostat, 370 × 80 × 45 cm. This is provided with thermo-regulators and stirrers, and can be maintained, at a constant temperature, to a hundredth of a degree. This can be used simultaneously, by six or eight students, and is particularly convenient in studying

chemical equilibrium, reaction, velocity, etc. This bath is not used for conductivity measurements, a separate room being provided for that purpose in a quiet part of the building.

Ostwald lays considerable stress upon a weekly meeting of professors, instructors and students, which he holds for the purpose of discussing investigations which are in progress or which have been completed. In this way he thinks the professor will gain a more accurate knowledge of what the student has done that his suggestions will be more adequate to the case, and that the student will acquire a broader view of the problem in his own hands, and a more systematic method of dealing with it.

One further provision in connection with this part of the laboratory is worthy of note. Physical chemistry involves a good deal of theory, and Ostwald has observed, doubtless, as the result of wide experience, that it gives rise to considerable discussion, especially on the part of beginners. Such discussions, even when purely scientific, naturally interfere also with those who are not taking part in them. He has provided a place in which these discussions can be carried on. The corridor is fitted up with black-boards, crayon and sponges. When the controversy becomes warm, the contestants can retire to the corridor, near the door, where it is cool, and here settle their differences in the most approved scientific manner. The gain to be derived to pure science from this provision may be considerable, especially in that men who are really working will not be disturbed by those who are simply talking.

The second story is a well equipped general chemical laboratory and scarcely calls for special comment. They are prepared in the new, as in the old, chemical laboratory, to give a student a general training in chemistry, which is absolutely essential to a subsequent career in physical chemistry.

The new laboratory was opened on January 3, 1898. There were present all the more prominent physical chemists of Germany and a number from outside: Van't Hoff, Arrhenius, Landolt, Beckmann, Waage, Nernst, Le Blanc, Elbs, Walden, Küster, and others. In addition to the physical chemists, there were those whose names are household words in other fields of natural science. Wislicenus, Wiedemann, Pfeffer, Engelmann, Flechsig, Zincke, Dorn, Knorr, and a number of the Leipsic faculty in more remote fields. Ostwald greeted his guests collectively and a number of them individually, and thanked most heartily, those who had made the new laboratory possible, and his assistants who had aided him in equipping it. He expressed the wish that "the spirit of brotherly frankness and the inspiring love of work, which accomplished so much in the old laboratory should remain true to the new. *Without this ethical content our work would be as sounding brass or a tinkling cymbal,*" and then gave way to Beckmann.

During the past year a circular letter was sent to all who had worked with Ostwald in the old laboratory, inviting them to contribute to a fund which would be used to secure a bust or portrait of their Teacher. This was to be presented to him at the opening of the new laboratory, as a token of the esteem in which he is held by those who know him best. This met with the heartiest response, and made it possible not only to secure a bust, but also a number of reliefs for the laboratory, of such men as *Scheele*, *Berthollet*, *Berzelius*, *Faraday*, *Liebig* and *Bunsen*.

Beckmann made a short address, in which he expressed the love and esteem felt for Ostwald by all who have worked under his guidance, and presented a sketch of him from the hand of the Leipsic artist Seffners, which is to be placed in Ostwald's home. This was received with that frank-

ness and humility which are so characteristic of the master; and this now brings us to the most important event of the day—the formal address of Ostwald.

The speaker did not think it desirable to take up a special topic in physical chemistry, because a number of those present were in other fields, and would scarcely have followed him. He, therefore, chose a more general subject, which touches all branches of science, and in which all must be interested—*The problem of time.* This problem is discussed at first philosophically, and then its direct bearing upon physical chemistry is pointed out. Newton regarded time as objective, and distinguished in his *Principia* between absolute and relative time, regarding the latter as being contained in the former. Kant took the opposite view, that time as well as space is subjective. But this idea did not exert its influence on the natural sciences until about the middle of this century. The experimental development of the physiology of sensation brought out the subjective nature of sense impressions so clearly that the importance of Kant's suggestion began to be felt. We must not regard our conception of time as complete, but recognize that it is affected by the physiological conditions of our existence. I regard time as the *most general natural law.* Natural laws have this characteristic: They allow the infinite variety of possibility to be reduced to a special case, or to special cases of reality, and their significance is the greater the more numerous and manifold the phenomena to which the reduction finds application. In this sense time is a natural law. The conception of time expresses relations which are repeated in very widely different phenomena.

Ostwald then proceeds to analyze our conception of time, and finds in it the following four elements :

First, continuity. Time moves on without interruption. During sleep we cannot recognize time, and should be led to conclude that it had been interrupted. But the consideration of the objective world, which has progressed during our sleep, shows that the discontinuity of time is only apparent, and that it has really progressed without interruption.

Second, the linear nature of time. Time is a constant magnitude of such a nature that it is possible to pass from one definite value to another, only *in one way.* This is the same as to designate time as having one dimension.

Third, time never returns to a point or value which has been once passed, and is thus to be distinguished from a line with which it has much in common, since a line can be easily so drawn that it will cut itself.

Fourth, time moves on in one definite order. This is absolute, and a given succession in time cannot be reversed.

After inquiring into the origin of our conception of these four elements into which time has been analyzed, the speaker then considered the bearing of this discussion upon physical chemistry. A very important chapter in physical chemistry is that which deals with the *velocity of reactions.* A solution of this problem would not only complete a chapter of the science, but would throw light upon the most fundamental questions of psychology, and consequently of philosophy.

The chemist Wenzel furnished the foundation, more than a hundred years ago, for the law which obtains for reaction velocity—that under the same conditions, the velocity is proportional to the concentration of the reacting substance. More careful investigation showed that reaction velocity depends upon the nature of the reacting substances, their concentration and temperature, and other conditions which influence it, entirely out of proportion to the apparent magnitude of the

cause which is operating. A very small amount of a foreign substance, which apparently did not enter into the reaction, was found to be capable of increasing the velocity of a reaction to a very great extent. Examples of such reactions have long been known; indeed, the transformation of starch into sugar by boiling with acids, has been known for more than a century. Such action on the part of a foreign substance was termed by Mitscherlich and by Berzelius 'catalytic.' Such effects have recently been classed under the general head of *changes in the reaction velocity*.

Two experiments were then performed illustrating both acceleration and retardation of reaction velocity. If to a dilute solution of potassium iodide an equivalent of potassium bromate and acetic acid is added, free iodine will separate very slowly, and this can be made visible by the presence of a little starch. If a drop of a solution of potassium bichromate or ferrous sulphate is added, the solution becomes blue in a few moments, showing an acceleration in the velocity of the reaction. The bichromate does not act as an oxidizing agent under these conditions, as can be shown by removing the iodine by means of sodium thiosulphate, when the solution will have the yellow color of the unreduced bichromate. Further, ferrous sulphate, which produces the same reaction, is a strong reducing agent.

The retardation of the velocity of reaction was shown as follows: When an acid is added to a dilute solution of sodium thiosulphate the solution becomes cloudy, after a time. The addition of sulphurous acid causes the solution to remain clear for a much longer time. This is probably not catalysis in the strict sense, but the action of mass. Yet there are cases known where the retardation is undoubtedly a catalytic action, but these are less suitable for the purpose of demonstration.

We have, then, in small amounts of catalyzers, a means of increasing or diminishing the velocity of reactions a thousand or a million times. Says Ostwald: "I should like to express my conviction that it is difficult to overestimate the importance of this for organic life."

But what may be the technical significance of catalytic action? To increase the velocity of machines a proportionally larger amount of work must be done. An express train carrying the same weight as a freight, but moving with greater velocity, will consume more coal in traveling the same distance. A galvanic cell will work more economically the smaller the strength of current. Also in the other technical fields *velocity is secured at the expense of energy.*

Only in chemcal processes is this avoided. The addition of a small amount of a catalyzer, which is not used up in the reaction, may enormously increase the velocity of a reaction.

The significance of this for the industries becomes apparent, when we consider how important is the element of time in carrying out technical processes. Could a catalyzer be found for such processes a factory using the same amount of machinery or apparatus could increase its productivity many fold, and thus save interest on capital invested; or a train could greatly increase its velocity with the same consumption of coal.

As a matter of fact, catalyzers have long been used in some of the industries, such as the manufacture of sulphuric acid, dyeing, bleaching, etc. But up to the present this has been purely empirical, and frequently the rôle played by the catalyzer has not been recognized. The intelligent application of catalytic processes to the industries has recently been begun, and this is entirely due to the scientific study of such processes.

"I regard the field of catalytic phenom-

ena as the one in which the next important advances in general chemistry will be made,'' says Ostwald, who concluded his address thus, the aim of physical chemistry is to discover relations between the different branches of science and, instead of increasing the gap between them, to be an important factor in effecting their union.

In the afternoon a banquet was given to those present and in the evening the students held a 'Kommers.'

Thus was opened the finest laboratory for physical chemistry now in existence, it being the fourth in Germany alone. That of Landolt, in Berlin, is the oldest, while the laboratories of van't Hoff, in Berlin, and Nernst, in Göttingen, have scarcely two years of history. When we consider these facts, and, in addition, the number of places in which physical chemical investigations are in progress, especially in other laboratories in Germany, in France, Russia, Scandinavia, Austria, Japan, Holland, Great Britain, and America, we recognize that this branch of science has taken its place among the more important natural sciences.

And when we consider, further, that work of the character of that which is described as belonging to the 'Leipsic school' has been in progress for only a little more than a decade of years, we are impressed by what has already been accomplished, especially in the way of generalization.

It is to Ostwald that we are indebted for the *Zeitschrift* in which investigations could be published; for the experimental verification of the most important theories, and for the systematic presentation of the facts, in his monumental work —the *Lehrbuch*.

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*WIRELESS TELEGRAPHY.**

DURING the last few months the Solent has been the scene of some interesting experiments in wireless telegraphy. Under the direction of Signor Marconi two stations have been fitted up—one in Bournemouth, just opposite the end of the pier, and the other at Alum Bay, in the Isle of Wight—and between these places, which are $14\frac{1}{2}$ miles apart, regular communication has been maintained without the use of any intervening connecting wires. On occasion an even greater distance has been traversed, for with portable instruments temporarily set up on the cliffs at Swanage it has been found possible to speak with the station at Alum Bay—nearly 18 miles away. But Signor Marconi does not believe that this represents anything like the limits up to which his apparatus can be worked, and he is now making the necessary arrangements for exchanging signals with Cherbourg, a distance of some 60 miles.

The instruments employed at Bournemouth and at Alum Bay are alike in all essential respects. The only outward sign at either place is a tall mast, some 120 feet high, from which depends a metallic conductor. Sometimes this is a simple wire; at others a narrow strip of ordinary wire netting has been tried as affording more electrical capacity, but there does not appear to be any great difference in the results. Inside the stations the first piece of apparatus that catches the eye is an induction coil capable of giving a spark 8 or 10 inches long. This with an appropriate battery and a key to control the current constitutes the sending instrument. The discharge from the coil passes between two brass balls about $1\frac{1}{2}$ inches apart, thus giving rise to electro-magnetic waves which are radiated in all directions. One of the balls is connected with the external conductor already mentioned, the other is put to earth. Some

* From the London *Times*.